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EDITORIAL COMMENT

Will 3D at 3-T Make Myocardial Stress Perfusion Magnetic Resonance Imaging Even More Competitive?*

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Currently, two-dimensional (2D) adenosine stress myocardial perfusion cardiac magnetic resonance imaging (MRI) uses 3 to 4 cardiac slices to cover the left ventricular myocardium. Although the performance of 2D adenosine stress myocardial perfusion MRI has been shown to be equal or even better compared with single-photon emission computed tomography (SPECT) because of its superior image resolution, this technique lacks complete myocardial coverage (1).

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Recent advances in MRI scanner technology and sequence design allow highly accelerated 3D myocardial perfusion imaging with improved signal homogeneity and better reconstruction accuracy of temporally resolved signal intensity curves (2). Joyiga et al. (3), in this issue of the *Journal*, use a 3-T MRI system. Higher field strength improves substantially image quality and test performance for cardiac stress perfusion imaging compared with lower field strength MRI (4,5). In this study, the increased signal-to-noise ratio at 3-T (about 30%) compared with 1.5-T MRI scanners was used for highly accelerated 3D image acquisition covering the whole ventricle in 1 heartbeat with an acceptable spatial resolution ($2.3 \times 2.3 \times 5$ mm^3) and diagnostic image quality.

The 3D adenosine stress myocardial perfusion MRI study by Jogiya et al. (3) used pressure wire derived fractional flow reserve as an endpoint. They showed improved specificity values with fractional flow reserve compared with quantitative coronary angiography (89.5% vs. 80.0 %), reflecting a lower false positive rate likely related to coronary arteries without functional flow limitation despite appearing significantly narrowed on quantitative coronary angiography. The functional assessment of coronary artery stenosis has been shown to be directly related to patient outcome and is part of the guidelines for patient work-up before revascularization therapy (6,7).

Should 3D instead of 2D myocardial stress perfusion MRI now be recommended for all patients undergoing potential revascularization therapy? This question still remains to be answered in larger trials. The good news of this study is that only 3 reconstructed evenly spaced short-axis perfusion slices of the 3D dataset did not show an inferior test performance in their patient cohort. With the technical limitations of not using a true 2D perfusion sequence, the data still showed that even with limited myocardial coverage, the performance of cardiac adenosine stress MRI with limited myocardial coverage was acceptable.

A recent meta-analysis by Hamon et al. (8) including 2,125 patients reported very similar performance values using only 2D vasodilator stress myocardial perfusion MRI with a sensitivity of 89% (95% confidence interval: 88% to 91%) and a specificity of 80% (95% confidence interval: 78% to 83%) compared with invasive angiography. It is also known that the analysis of myocardial late gadolinium enhancement imaging in conjunction with the myocardial stress perfusion MR images—as implemented in the current study—improves the specificity of cardiac adenosine stress MRI (9). In addition, there is growing evidence that adenosine stress MRI provides strong prognostic value for patients with suspected coronary artery disease. A normal MRI cardiac stress test predicted a 3-year cumulative cardiac event rate of 0.8% versus 16.5% in patients with an abnormal stress MRI examination in a single center study with 513 patients using a combined adenosine stress perfusion and dobutamine stress MRI examination (10).

How does 3D perfusion MRI compare with other stress perfusion imaging tests? SPECT is still the most widely used stress perfusion test that exposes the patient to radiation. In a recent study including 752 patients (CE-MARC [Clinical Evaluation of MAgnetic Resonance imaging in Coronary heart disease study]), a comprehensive cardiac MRI protocol that included 2D adenosine stress MRI using 3 short-axis slices showed a significantly superior test performance compared with SPECT; it had a higher sensitivity and negative predictive value to detect significant coronary artery disease using conventional angiography as the gold standard (11). With the extended myocardial coverage compared with the 2D MRI method, 3D MRI should have at least a similar performance. Compared with SPECT, the far less frequently used positron emission computed tomography (PET) adenosine stress myocardial perfusion imaging test has a higher spatial resolution (12). However, large multicenter data are still not available comparing PET with MRI. Novel hybrid PET-MRI technol-

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ogy enabling a simultaneous PET and MRI adenosine stress myocardial perfusion measurement will likely be positioned to tackle this question.

Future trials have to show that this novel 3D MRI perfusion technique at 3-T is robust and can be applied in a multicenter setting including various MRI vendors. Also, the feasibility and potential clinical application of quantitative 3D MRI perfusion measurements in ischemic and nonischemic heart disease—as already shown with 2D perfusion MRI and PET—has to be evaluated in future research (13–15).

Cardiac adenosine stress perfusion MRI has undergone many technical improvements and several levels of clinical validation over the last decade, with rapidly increasing clinical use worldwide. We look forward to the application of novel 3D MRI adenosine stress perfusion techniques like those described by Jogiya et al. (3) for comprehensive and highly competitive noninvasive assessment of patients with suspected coronary artery disease before revascularization therapy.

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